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The funds have been used entirely to support a CUNY Ph.D. student who has conducted extensive measurements of the magnetic properties of molecular magnets Most of the attention was directed toward experimentally studying quantum tunneling of magnetism in Mn12-acetate.

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FINAL REPORT
ON
AASERT GRANT AWARD No. F49620-97-1-0403

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The funds have been used entirely to support the U.S. citizen CUNY Ph.D. student Kevin Mertes. Kevin has conducted extensive measurements of the magnetic properties of molecular magnets. Most of his attention has been directed toward experimentally studying quantum tunneling of magnetism in Mn12-acetate. In order to accomplish this, Kevin had to first construct a Hall bar measurement system that would fit within an Oxford Heliox Cryostat. This task required that he designed and built a sample holding apparatus. During this phase of his work he established a technique of mounting the sub-millimeter crystals onto the Hall bar detector without damaging the detector or breaking the extremely fragile crystals. His previous experience in low current measurements allowed him to quickly devise the external electronics necessary for Hall bar measurements. The magnetization measurements that he planned to make required extensive computer control. To this end he wrote from scratch an entire library of software routines that allow simple acquisition of data for a variety of experiments. This will help alleviate the burden of designing a computer interface for future students.

Kevin's first set of measurements was designed to measure in detail the steps in the magnetization curves of Mn12-acetate. These steps have been attributed to tunneling of spin. Kevin's experiment was aimed at establishing exactly how the population of each energy level contributes to the tunneling process. He has been able to establish experimentally that at temperatures below approximately 600mK only the ground state contributes to tunneling. The externally applied fields at which these transitions occur agree extremely well with theoretically predicted values. Interestingly, these predicted values depend upon parameters that were experimentally determined in completely different neutron scattering experiments.

In addition to establishing that Mn12-acetate can tunnel from the ground state at temperatures below approximately 600mK, Kevin studied the transition from ground state tunneling to excited state tunneling. By increasing the temperature of the crystal, the population of levels that are higher in energy will also increase. Thus, changing the temperature changes the population distribution of the energy levels. This, allows Kevin to probe how the different tunneling paths contribute to the tunneling process. Paradoxically, Kevin found that as the temperature increases, tunneling from the ground state suddenly disappears. This observation required extensive analysis of reams of data that he collected over a period of several months. A

satisfactory explanation of this phenomenon has yet to come to fruition. But Kevin has proposed several explanations for the paradoxical behavior and has already devised two experiments that can be used to establish the veracity of some of his proposed explanations.

Kevin has discussed the establishment of the existence of tunneling from the ground state in Mn12-acetate, as well as, the general nature of quantum tunneling at two conferences, The Indo-French Workshop on Current Trends in Molecular Magnetism and The 8th Joint MMM-Intermag Conference. His talks were well received. In fact, one senior researcher commented that "I never really understood all this quantum tunneling of magnetism until I heard Kevin's talk." He has also attended other conferences such as the International Conference on Magnetism-2000, Nuclear Methods in Magnetism-2000, 3rd Euro-Conference on Magnetic Properties of Fine Particles and their Relevance to Materials Science, and 44th Annual Conference on Magnetism & Magnetic Materials where he learned in detail what other researchers are studying. At these conferences Kevin established good ties with fellow researches and was able to formulate ideas for his own research.

In addition, Kevin has also published on the topic of molecular magnetism as well as on the two-dimensional electron system (2DES) found within Si-MOSFETS. His work in 2DES was part of his basic laboratory training. Since his contributions were instrumental to the successful completion of these experiments, he has been included as a contributing author on the publications resulting from the 2DES experiments. He even gave a talk at the 1999 APS March meeting, regarding the unexpected response of the 2DES in a parallel magnetic field.

A complete list of his publications in physics is shown below:

PUBLICATIONS:

"Abrupt Transition between Thermally-Assisted and Pure Quantum Tunneling in Mn-12," K. M. Mertes, Yicheng Zhong, M. P. Sarachik, Y. Paltiel, H. Shtrikman, E. Zeldov, Evan Rumberger, and D. N. Henderson, to be published in Macroscopic Quantum Coherence and Quantum Computing, (Kluwer Academic Plenum Publishers, 2000).

"Abrupt Transition between Thermally-Assisted and Pure Quantum Tunneling in Mn12-Acetate," K. M. Mertes, M. P. Sarachik, Y. Paltiel, H. Shtrikman, E. Zeldov, Evan Rumberger, and D. N. Henderson, to be published in Jour. Appl. Phys., April (2001).

"Abrupt Transition between Thermally-Assisted and Pure Quantum Tunneling in Mn12-Acetate," K. M. Mertes, Yicheng Zhong, M. P. Sarachik, Y. Paltiel, H. Shtrikman, E. Zeldov, Evan Rumberger, and D. N. Henderson, submitted to Phys. Rev. Lett.

"Magnetoconductance of the Anomalous 2D Conducting Phase in Parallel Field," D. Simonian, S. V. Kravchenko, K. M. Mertes, M. P. Sarachik, and V. M. Pudalov, Physica B **256-258**, 607 (1998).

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"Response to a Parallel Magnetic Field Across the M-I Transition," K. Mertes, D. Simonian, M. P. Sarachik, S. V. Kravchenko, and T. M. Klapwijk, Phys. Rev. B **60**, R5093 (1999).

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"Small-angle Shubnikov-de Haas Oscillations in Silicon MOSFET's," S. A. Vitkalov , Hairong Zheng, K. M. Mertes, M. P. Sarachik, and T. M. Klapwijk, Phys. Rev. Lett. **85**, 2164 (2000).

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"Hall Coefficient of a Dilute 2D Electrons System in Parallel Magnetic Field," S. A. Vitkalov, H. Zheng, K. M. Mertes, M. P. Sarachik, and T. M. Klapwijk, to be published in Phys. Rev. B. Rapid Communications; preprint cond-mat/0008456 (2000).

"Evidence for a Quantum Phase Transition to a Ferromagnetic Ground State in a 2D Electron System," S. A. Vitkalov, H. Zheng, K. M. Mertes, M. P. Sarachik, and T. M. Klapwijk, submitted to Phys. Rev. Lett.; preprint cond-mat/0009454 (2000).

ORAL PRESENTATIONS:

"Tunneling in Mn12-Acetate," K. M. Mertes, M. P. Sarachik, Y. Paltiel, H. Shtrikman, E. Zeldov, Evan Rumberger, and D. N. Henderson, APS March meeting, Seattle (2001).

"Mesoscopic Quantum Tunneling of Magnetism in Mn12-Acetate," K. M. Mertes, M. P. Sarachik, E. M. Chudnovsky, Indo-French Workshop, Bangalore, India (2000).

"Response of a Dilute 2D Electron System to a Parallel Magnetic Field," K. M. Mertes, M. P. Sarachik, S. V. Kravchenko, D. Simonian, T. M. Klapwijk, APS March Meeting, Atlanta (1999).

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